1.0 GENERAL

THESE COMMENTS ARE BASED ON A DETAILED KNOWLEDGE OF THE VEHICLE AND REQUIREMENTS INCLUDED IN THE SPECIFICATION CONTENT OF ART'S AND THE C&J PROPOSAL, A REVIEW OF ROD'S PROPOSAL AND A VERBAL BRIEFING ON T'S PROPOSAL.

AN ATTEMPT IS MADE TO COMPARE THEM USING THE SALIENT POINTS WHICH ARE APPARANT TO ME.

THE COMPARISON IS MADE BY MAJOR COMPONENT OR SUB SYSTEM FIRST, FOLLOWED BY SOME OVERALL COMMENTS.

2.0 DETAILED COMPARISON

A BRIEF COMMENT IS MADE WHERE I HAVE OPINIONS OR KNOWLEDGE ON EACH OF THE MAJOR SECTIONS.

2.1 OPTICS

ROD'S - 18" F.L. MODIFIED SCHMIDT REQUIRING MIRRORS IN AN APPROXIMATELY 30" LONG BARREL INTRINSIC IMAGE QUALITY IS PROBABLY BEST BUT BOTH MANUFACTURING FOR LIGHT WEIGHT AND MOUNTING DIFFICULTY MAY LIMIT RESULTS SLIGHTLY.

ARTS' - 21" F.L. REFRACTING LENS WITH SCAN MIRROR AND FOLDING MIRROR. IMAGE QUALITY GOOD BASED ON RESULTS OF EXISTING LENS AND BECAUSE OF LONGER FOCAL LENGTH AND LESS DIFFICULT MOUNTING PROBLEMS. RESULTS WILL PROBABLY BE VERY NEARLY EQUAL TO ROD'S'.

14 con → T'S - 48" F.L. TELEPHOTO 18"X18" COVERAGE. SINGLE SCAN MIRROR IN FRONT EVEN WITH A CONTOURED PLATEN THE LOW CONTRAST RESOLUTION WILL PROBABLY BE IN THE 35 TO 40 L.P.M. RANGE WHICH MAKES THE POSSIBLE ANGULAR RESOLUTION APPROXIMATELY COMPARABLE TO ROD'S AND ARTS'. THE LENS WILL BE HEAVY.

T'S - 60" F.L. TELEPHOTO 18"X18" THE LOW CONTRAST RESOLUTION WILL PROBABLY BE IN THE 35 TO 40 L.P.M. RANGE. WITH THE LONGER FOCAL LENGTH, THE ANGULAR RESOLUTION COULD BE SLIGHTLY BETTER THAN ROD'S OR ARTS' BUT INDUCED VIBRATION OF FAST CYCLING MAY LOSE ALL THE ADVANTAGE OF INCREASED SCALE.

C&J'S - A 36" F/10 LENS SCAN MIRROR BEHIND LENS HAS GOOD LOW CONTRAST RESOLUTION IN THE 55 LPM RANGE. THE RESULTS WILL BE LIMITED BECAUSE OF THERMAL ENVIRONMENT AND VIBRATION. 18"X18" COVERAGE.

2.2 WINDOW

ROD'S THE LARGEST WINDOW AREA IS REQUIRED BECAUSE OF THE CONTINUOUSLY ROTATING FOUR SIDED SCAN MIRROR WHICH CAN'T BE MOUNTED CLOSE AND THUS MIMIMIZE WINDOW SIZE. THE LARGE SIZE REQUIRES A THREE LAYER EVACUATED WINDOW SANDWICH WITH A PROPOSED CAPPING SHUTTER SYNCHRONIZED TO THE SLIT TO LIMIT THERMAL INPUT AND THERMAL DISTURBANCE TO THE CAMERA OPTICAL PATH.

ART'S THE SCAN MIRROR PIVOTS NEAR THE WINDOW AND THE TWO PANORAMIC CAMERAS ARE CONVERGENT THUS ALLOWING THE USE OF A SINGLE RELATIVELY SMALL WINDOW. WITH THIS SMALL AREA, A SINGLE THICKNESS WINDOW CAN BE CONSIDERED WHICH WITH A SUITABLE COATING WILL HAVE A TOLERABLE THERMAL IMPUT TO THE "Q" BAY. BY ALLOWING THE REFRACTIVE OPTICS TO STABILIZE AT A RELATIVELY HIGH TEMPERATURE THERMAL DEGRADATION FROM GRADIENTS CAN BE AVOIDED USING HELIUM IN THE BAY WILL LIMIT CONVECTION TURBULENCE OPTICAL DEGRADATION TO A LOW VALUE.

T'S 48" & 60" REQUIRE MULTIPLE WINDOWS WITH A SHUTTER ON EACH WINDOW. THE "Q" BAY WILL BE CONSIDERED A LIGHT TIGHT BOX IN THIS DESIGN. THE THERMAL INPUT SHOULD BE LOW TEMPERATURE.GRADIENTS IN AND AROUND THE WINDOW WILL HAVE TO BE CONSIDERED IN THE DESIGN. PROBABLY SHUTTER, WINDOWS AND Q BAY AREAS WILL HAVE TO HAVE CONSIDERABLE EMPIRICAL [redacted] WORK TO AVOID IMAGE DEGRADATION. I BELIEVE IT CAN BE DONE WITH CONSIDERABLE EFFORT INVOLVING FULL SCALE MOCK UP AND THERMAL TESTING WITH SIMULATED OPTICAL TARGETS.

C&J THE FIVE SMALL WINDOWS ARE PLANNED AS A TWO LAYER VACUUM PACK AND DO NOT REPRESENT A CRITICAL PROBLEM. THE CONVECTION IMAGE DEGRADATION FROM THE HOT INNER WINDOW SURFACES WILL NOT BE ANY MORE SERIOUS IN THIS UNIT THAN IN THE OTHERS PARTICULARILY IF HELIUM IS USED.

2.3 STEREO ANGLE

ROD'S FORWARD OVERLAP ON VERTICAL CAMERAS APPROX 10 DEGREES

ART'S CONVERGENT STEREO APPROX 20 DEGREES

T'S FORWARD OVERLAP STEREO APPROX 10 DEGRESS FOR 48" F.L., APPROX 8 AND 1/2 FOR 60" F.L.

C&J FORWARD OVERLAP STEREO APPROX 14 DEGREES. THE HIGHER STEREO ACUITY AVAILABLE WITH ANGLES LARGER THAN 10 DEGREES IS A VALUABLE TOOL.

2.4 FILM TRANSPORT

RODS THE DESIRE FOR ABSOLUTELY SMOOTH AND CONTINUOUS MOTION THROUGH OUT THE FILM TRANSPORT, TOGETHER WITH THE SPACE USED BY THE 30" LENS PATH LENGTH FORCES A MOST COMPLEX AND DIFFICULT FILM TRANSPORT ON ROD'S CAMERA. A SINGLE STRIP OF FILM GOES PAST BOTH SLITS WITH ONE SLIT INTERPOSING ITS IMAGE BETWEEN SCAN SWEEPS OF THE OTHER CAMERA. BECAUSE OF SPACE LIMITATION AND THE DESIRE TO HAVE ZERO FILM C.G. SHIFT A COAXIAL REEL IS PLANNED. ALL OF THESE REQUIRE AT LEAST SIX FILM TWISTERS WHICH AT BEST ARE HAZARDOUS. THE INTERNAL TIMING BETWEEN CAMERAS IS BEING HANDLED ENTIRELY BY SERVO MEANS WITH NO MECHANICALLY LOCKED PHASING BETWEEN CAMERAS. THUS IT IS THE SAME FILM STRIP. THIS IS ALSO DIFFICULT AND HAZARDOUS. AT BEST THE FILM TRANSPORT IS A

SECRET

DIFFICULT AND LEGTHY DEVELOPMENT. BECAUSE OF THE LONG FILM PATHS INVOLVED THE PROCESS OF PROVIDING AN ISOLATED CHAMBER WITH A CONTROLLED ENVIRONMENT IS EXTREMELY COMPLEX AND COST DIFFICULT TO DESIGN AND ALMOST IMPOSSIBLE TO MAKE A REASONABLE OPERATIONAL DEVICE FOR SERVICING.

ARTS' THESE CAMERAS HAVE SEPARATE PRESSURIZED AND COOLED FILM CASSETTES FOR EACH CAMERA. THE TWO CAMERAS SPOOL IN OPPOSITE DIRECTIONS AND THUS AVOID ANY LARGE C.G. SHIFT OF THE FILM. THE FILM TRANSPORT IS STRAIGHT THROUGH AND THE INTERMITTENT FILM MOTION IS PROVIDED BY MERELY STOPPING THE FILM AND LETTING IT LIFT OFF AND DE-COUPLE FROM THE CONTINUOUSLY ROTATING PLATTEN ROLLER. AS THE ONLY INTERMITTENCY IS THE PLATEN METERING ROLLERS AND THE SHORT LENGTH OF FILM ON THE PLATEN, NO SIGNIFICANT VIBRATION IS EXPECTED FROM THE FILM TRANSPORT. IT IS ESSSENTIALLY A SIMPLE SMOOTH FILM ACTION WITH CONSTANT SPEED SPOOLING. ACCURATE PHASING BETWEEN THE CAMERAS TO PROVIDE A FIXED ANGLE BETWEEN SCANS IS ACHIEVED BY A SINGLE MOTOR DRIVE. THIS IS DONE TO PROVIDE A POWERFUL PHOTOGRAMMETRIC TOOL. IT IS NOT REQUIRED FOR FILM HANDLING.

T'S THE 48" & 60" FILM TRANSPORTS MUST BE EXTREMELY FAST CYCLING (APPROXIMATELY TWO PER SECOND). THIS IS DIFFICULT AND WILL CAUSE SEVERE INTERNAL VIBRATION AND PROBABLY IMAGE DEGRADATION. TWO PER SECOND IS THE FASTEST FEASIBLE 18" FILM TRANSPORT DEVELOPED TO DATE AND IT WAS NOT SATISFCATORY FROM AN INTERNAL SHOCK AND VIBRATION VIEWPOINT. ACHIEVING HIGH GROUND RESOLUTION WITH A LARGE FAST CYCLING FRAME CAMERA IS A DIFFICULT AND POSSIBLY UNSUCCESSFUL DEVELOPMENT. NO GOOD FAST CYCLING (2 PER SECOND OR FASTER) LARGE (18") FRAMING CAMERAS HAVE EVER BEEN DEVELOPED THOUGH SEVERAL HAVE BEEN ATTEMPTED.

C&J THE EXISTING "B" UNIT WILL BE USED ESSENTIALLY AS IT IS WITH THE CYCLING PERIOD ABOUT 70 PERCENT FASTER - IE - 1 AND 1/4 SECONDS BETWEEN EXPOSURES VERSUS THE PRESENT 2 AND 1/5 SECONDS BETWEEN EXPOSURES. THIS CAN BE READILY ACHIEVED WITHOUT MAJOR CHANGE IN THE CAMERA. THIS CAMERA A RELIABLE AND FULLY DEVELOPED UNIT WITH THE LOWER GROUND RESOLUTION EXPECTED . THE FILM TRANSPORT DISTURBANCES WILL NOT LIMIT THE RESULTS.

2.5 IMC

ROD'S CAMERA PROPOSES TO ACHIEVE IMC BY SHIFTING THE FILM SIDEWAYS ALONG THE SLIT BY MEANS OF SERVO CONTROLLED "TOE-IN" ROLLERS. AS IT IS IMPOSSIBLE TO GUIDE OR PUSH THIN BASE FILM BY EDGE GUIDES OR FLANGES, THE ONLY MEANS OF ACHIEVING PROPER IMC VELOCITY IS TO CONTROL THE RATE OF "TOE-IN" OF ROLLERS SO THAT THE FILM WILL MOVE AXIALLY ALONG THE ROLLERS AT THE PROPER RATE. THIS APPEARS TO BE A MOST DIFFICULT TECHNIQUE WHICH WILL BE SUBJECT TO ALL THE VAGARIES OF FILM TENSION, FILM CONDITION AND TRANSPORT SMOOTHNESS. IT DOES NOT APPEAR TO BE PRACTICAL FOR REASONABLE IMC ACCURACY.

ARTS' IMC IS PROPOSED TO BE ACHIEVED BY A SKEWING OF THE PRIMARY SCAN MIRROR AXIS TOGETHER WITH A COORDINATED IMAGE DE-ROTATION AMOTION OF THE FOLDING MIRROR. ALTERNATELY IT MAY BE PLANNED TO SWEEP THE STABILIZED MOUNT IN PITCH. EITHER METHOD WILL PROVIDE GOOD RESULTS THOUGH THE MIRROR SYSTEM WILL HAVE LESS WEIGHT.

T'S PROPOSAL IS TO ACHIEVE IMC BY MIRROR MOTION ABOUT A HORIZONTAL AXIS WHICH IS IN ADDITION TO THE SCAN MOTION. THIS IS PRACTICAL AND STRAIGHTFORWARD AND WORKED WELL IN THE ORIGINAL "C". CAMERA ACCURACY SHOULD BE GOOD.

C&J CAMERA ACHIEVES IMC BY ROCKING THE OPTICAL STRUCTURE AROUND A HORIZONTAL AXIS BY CAM DRIVE. EVEN WITH A X3 INCREASE IN RATE THE MOTION IS VERY SLOW AND GOOD IMC AND SMOOTH MOTION SHOULD RESULT. A CHANGE IN CAM AND STIFFENING OF FOLLOWERS AND SHAFTS WILL BE NECESSARY BUT RELATIVELY SIMPLE.

3.0 ESTIMATE OF GROUND RESOLUTION POSSIBLE

BASED ON EXPERIENCE WITH THE ORIGINAL "C" UNIT AND UTILIZING ESTIMATES FROM DATA AND METHOI IN NIELSON'S REPORT ON OPTICAL DEGRADITION THROUGH SHOCK AND BOUNDARY LAYER, FOLLOWING IS MY ROUGH ESTIMATE OF THE POSSIBILITIES UNDER PLANNED OPERATIONAL ENVIRONMENT USING ANGULAR RESOLUTION AS THE BASIS OF COMPARISON ORIGINAL "C" BEST RESULTS WERE 30 LPM WHICH RESULTED IN 6" GROUND RESOLUTION AND AND ANGULAR RESOLUTION OF .0073 MIL RADIUS USING NIELSON'S METHOD IT IS ESTIMATED THAT RESULTS IN THE "Q" BAY THROUGH BOUNDARY LAYER AND SHOCK WARE WILL BE LIMITED TO .01 MIL RADIUS ANGULAR RESOLUTION. THEREFORE THE "O" PROJECT RESULTS CAN PROBABLY NOT BE PUSHED BEYOND A GROUND RESOLUTION OF APPROXIMATELY 9 TO 10 INCHES

ROD'S CAMERA IS PLANNED FOR 1 FOOT

ART'S CAMERA IS PLANNED FOR 1 AND 1/2 FOOT

ARTS IS LESS THAN RODS ONLY BECAUSE OF THE LONGER SLANT RANGE BECAUSE OF CONVERGENT STEREO. IT IS BELIEVED THAT THE HIGHER STEREO ACUITY IS A BETTER TOOL THAN THE 1 FOOT WITH POORER STEREO.

T'S CAMERAS ARE LIMITED TO 9 TO 10 INCHES BY EXTERNAL DEGRADATION SO THE ADVANTAGES IN SCALE OF THE LONG FOCAL LENGTHS ARE LOST. THERE IS A GREAT DEAL OF DOUBT THAT EVEN THIS

RESOLUTION CAN BE ACHIEVED DUE TO INTERNAL VIBRATION DIFFICULTIES BECAUSE OF FAST CYCLING REQUIRED BY LONG FOCAL LENGTH.

C&J COVERAGE WITH [illegible] AND EXTERNAL THERMAL DEGRADATION IS EXPECTED TO PRODUCE 3.3 FEET GROUND RESOLUTION WHICH IS AN ANGULOR RESOLUTION OF .027 MIL RADIUS THE LENS ITSELF IS CAPABLE OF BETTER THAN .02 MIL RADIOUS AT LOW CONTRAST AND AT HIGH CONTRAST GOES TO .01 MIL RADIUS APPROXIMATELY. THEREFORE THE LENS IN THIS CAMERA IS A GOOD ONE.

4.0 ROUGH RELIABILITY COMPARISON BY SYSTEM COMPLEXITY

ROD'S CAMERA SYSTEM IS X MOST COMPLEX AND HAS MOSTLY ACTIVE ELECTRONIC ELEMENTS DETERMINING ITS INTERNAL SYNCHRONIZATION, PHASING AND ACCURACY AND HAS A MOST DIFFICULT FILM PATH. THE DEVELOPMENT PROCESS WILL BE A LENGTHY AND DIFFICULT ONE TO ACHIEVE RELIABILITY.

ARTS CAMERA SYSTEM EMPLOYS PASSIVE INTERNAL SYNCHRONIZATION AND PHASING (MECHANICAL LOCK) AND HAS A SIMPLE STRAIGHT FILM PATH. THE DEVELOPMENT IS PRIMARILY APPLICATION OF GOOD DESIGN PRACTICE TO ACHIEVE RELIABILITY.

T'S CAMERAS ARE SIMPLE AND EXCEPT FOR THE FAST CYCLING WOULD BE STRAIGHFORWARD. ACHIEVING RELIABILITY AND GOOD RESULTS WILL BE A DIFFICULT AND LENGTHY PROCESS.

C&J CAMERA IS OF PROVEN RELIABILITY. THE FASTER CYCLING REQUIRES MIMIMUM MODIFICATION. THE CYCLING RATE IS MODERATE AND SHOULD NOT REPRESENT A RELIABILITY PROBLEM.

5.0 VIBRATION ISOLATION & STABILIZATION

ALL PROPOSALS EXCEPT C&J PLAN TO USE A C.G. FREE-FREE MOUNTING WITH STABILIZING TORQUERS REFERENCED TO INERTIAL SPACE. ROD PLANS TO USE FLYWHEEL REACTION TORQUES RATHER THAN PUSH-PULL SOLENOIDS. A SLIGHTLY BETTER STABILIZATION QUALITY CAN BE ACHIEVED BUT THERE IS DOUBT THAT THE EXTRA WEIGHT IS WARRANTED AS THE ORIGINAL "C" UNIT ACHIEVED A CONSIDERABLY BETTER ANGULAR RESOLUTION THAN IS NOW PLANNED. THE ONLY DETAILED VIBRATION ISOLATION SYSTEM PROPOSED WAS IN ARTS' PROPOSAL IN WHICH THE VIBRATION DAMPERS ARE REFERENCED TO INERTIAL SPACE. THIS SYSTEM SHOULD AVOID MANY OF THE VIBRATION DIFFICULTIES EXPERIENCED WITH THE ORIGINAL "C" UNIT. THE C&J CAMERA IS NOT PLANNED FOR EITHER DYNAMIC VIBRATION ISOLATION OR STABILIZATION. THE EXPECTED QUALITY OF RESULTS DOES NOT WARRANT IT. THE VEHICLE IS VERY SMOOTH.

[redacted] SUMMARY

RODS CAMERA HAS INTRINSIC POSSIBILITY OF HIGHEST QUALITY RESULTS BUT THE PROBABILITY IS THAT EXTERNAL CONDITIONS LIMIT THE RESULTS. THE PRICE PAID IN COMPLEXITY AND DIFFICULTY OF DEVELOPMENT FOR AVOIDING ANY INTERMITTENT MOTIONS WHATSOEVER (EXCEPT IMC) IS EXTREME.

ARTS CAMERA WILL PROBABLY PRODUCE THE SAME INFORMATION CONTENT AS RODS AND IS A MUCH SIMPLER AND ACHIEVABLE DESIGN.

T'S CAMERAS CANNOT BE USED TO THEIR FULL ADVANTAGE IN THIS VEHICLE BECAUSE OF CONSEQUENT FAST CYCLING AND EXTERNAL RESOLUTION LIMITATIONS.

C&J CAMERA IS A QUICKLY AVAILABLE INTERIM UNIT WHICH WILL PRODUCE USEFUL RESULTS.

THE COVERAGE OF RODS, ARTS, AND C&J CAMERAS ARE ROUGHLY THE SAME. T'S CAMERAS ARE PROBABLY WEIGHT LIMITED IN COVERAGE.